Prevalence of Respiratory Conditions among Schoolchildren Exposed to Different Levels of Air Pollutants in the Haifa Bay Area, Israel

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During spring 1984, 2334 second and 2000 fifth-grade schoolchildren living in three Haifa Bay areas on the eastern Mediterranean coast with different levels of air pollution were studied. The parents of these children filled out American Thoracic Society and National Heart and Lung Institute health questionnaires, and the children performed the following pulmonary function tests (PFT): FVC, FEV_1, FEV_1/FEV, PEF, FEF_{50}, and FEF_{75}. A trend of higher prevalence of most reported respiratory symptoms was found for schoolchildren growing up in the medium and high pollution areas as compared with the low pollution area. Part of the reported respiratory diseases were significantly more common among children from the high pollution area. Models fitted for the respiratory conditions that differed significantly among the three areas of residence also included background variables that could be responsible for these differences. Relative risk values, which were calculated from the logistic models, were in the range of 1.38 for sputum with cold and 1.81 for sputum without cold for children from the high pollution area as compared with 1.00 for children from the low pollution area. All the measured values of PFT were within the normal range. There was no consistent trend of reduced pulmonary function that characterized any residential area.

Introduction

Health outcomes as a result of exposure to air pollutants have been studied in many countries during the last decades. A special effort is being made to detect health effects resulting from long-term exposure to concentrations of pollutants prevailing in communities. In the last two decades many environmental surveys were carried out among children, who are not occupationally exposed and do not smoke, taking into account many other factors to which they are exposed and which may affect their respiratory system in the same way as air pollution (1–16).

In this study we compared the health status of children growing up in three Haifa Bay areas with different levels of air pollution, taking into account other environmental factors to which they are simultaneously exposed.

Materials and Methods

The Haifa Bay region is one of the most polluted in Israel. The two main industries contributing to the air pollution in this region are refineries distilling five to six million tons of crude oil per year (with relatively high sulfur content) and operating a 26 MW power plant; and an electricity-producing

oil-fired power plant with a capacity of 450 MW. A complex industrial zone, which includes among other a fertilizer plant, a cement factory, and many other chemical plants, also exists in this area (Fig. 1).
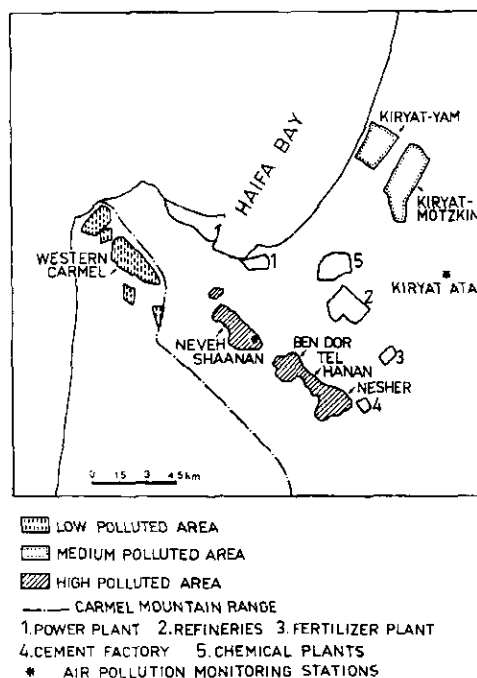

LOW POLLUTED AREA
MEDIUM POLLUTED AREA
HIGH POLLUTED AREA
— · — CARMEL MOUNTAIN RANGE
1.POWER PLANT 2.REFINERIES 3.FERTILIZER PLANT
4.CEMENT FACTORY 5.CHEMICAL PLANTS
* AIR POLLUTION MONITORING STATIONS

FIGURE 1. Haifa Bay region: sites of pollution sources, air pollution monitoring stations, communities studied.

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The Carmel mountain range, which extends in a northwest direction, creates a 2-km wide and 12-km long bay in the Mediterranean Sea. The main climatic characteristics that determine the air pollution in the bay are: a) the surface winds regime; b) the thermal stability of the air layer near the surface; c) high altitude winds regime; d) the thermal stability in the layer up to 500 to 600 m. The air pollutants emitted from the refineries, from the power plant, and from other sources are mixed within a 500-m air layer. Since the Carmel mountain range is also about 500 m high, it usually prevents the passage of pollution to the south and southwest, thus leaving the western Carmel a relatively unpolluted area.

Study Population

Second- and fifth-grade pupils from 27 Haifa Bay schools were studied during the spring of 1984. The children lived in three areas with different air pollution levels: high (Neveh Shaanan, Ben-Dor, Tel Hanan, and Nesher), medium (Kiryat Yam, and Kiryat Motzkin), and low (Western Carmel) (Fig. 1).

Health Questionnaires

The health questionnaire (17) used in this study is a translation into Hebrew of the ATS-NHLI (American Thoracic Society and the National Heart and Lung Institute) health questionnaire, to be self-administered by the children's parents. The questionnaires were distributed between March and June by the school nurses, who also collected them after they had been filled out. The following information was obtained from the health questionnaires: respiratory symptoms and diseases of the children, socioeconomic status, type of household fuel used, smoking habits of the parents, father's country of origin, and respiratory problems among the children's parents.

Pulmonary Function Tests

Pulmonary function tests (PFT) consisted of forced vital capacity (FVC), forced expiratory volume in first second (FEV$_1$), FEV$_1$/FVC, peak expiratory flow (PEF), forced expiratory flow in 50% volume (FEF$_{50}$), and forced expiratory flow in 75% volume (FEF$_{75}$). PFT were carried out by a trained technician using a Minato AS-500 portable spirometer (ATS approved). The expiratory maneuver was carried out with the subject standing and was repeated at least three times until two similar tests (agreed within 10%) were achieved. The best test (highest FVC + FEV$_1$) was chosen. All the participants were weighed and their height measured before carrying out the expiratory maneuver.

Analytic Procedure

Statistical analysis of the data was carried out by means of the SPSS program (18). Prevalence of reported respiratory symptoms and diseases according to place of residence was analyzed by means of the chi-square test for examination of independence between two variables. The possible effect of a different distribution of background variables in the three

areas of residence was examined by stratification.

In order to examine the combined effect of all variables in each area, a nonhierarchical logistic model (19) was fitted for the frequency of each respiratory symptom or disease. Those background variables that were included in the logistic regression for each population and area of residence were included in the logistic model fitted for the respiratory condition in the pooled data set of the three populations. The equation for the predicted proportion of children with the respiratory condition E(f/n) according to the logistic regression is:

$$E(f/n) = \frac{e^u}{1 + e^u}$$

where

f is the frequency of the respiratory condition;
n is the sample size;
$u = a + b_1 x_1 + b_2 x_2 + \ldots + b_m x_m,$
and $x_1, x_2 \ldots x_m$ are the background (binary) variables and $a, b_1, b_2 \ldots b_m$ are the coefficients.

The logistic regression estimates the coefficients of the background variables (such as country of origin, socioeconomic status, type of household fuel used, smoking habits, and respiratory diseases in the family) in a stepwise manner.

The relative risk (RR) to suffer from a respiratory condition in the polluted communities as compared with the low-pollution community was calculated from the logistic regression as follows: RR = e^{β_1} where β_1 is the coefficient of the area of residence.

PFT in the three areas were first analyzed by means of one-way analysis of variance. The possible effect of background variables on PFT was analyzed by multiple regression analysis, which took into account those variables whose frequencies differed significantly between the areas. As the area was entered last into the multiple regression, its effect could be demonstrated after the effect of other background variables that could act similarly was eliminated.

Air Pollution Measurements

Air pollution measurements in the Haifa Bay region in 1984 were carried out by the Israel Electric Company and the Haifa Municipality. In the studied areas, two automatic monitoring stations, located in Nevah Shaanan and Kiryat-Ata (Fig. 1), measured sulfur dioxide (SO$_2$), nitrogen oxides (NO$_x$), soiling index, and meteorological parameters. SO$_2$ was measured using a conductometric detector apparatus. NO$_x$ was measured using a chemiluminescent instrument. Air pollution is not routinely measured in the low pollution area. Only sporadic measurements were carried out in this area by the Ministry of Health.

Results

Air Pollution Measurements

Table 1 summarizes air pollution measurements carried out in the Haifa Bay region during 1982 to 1984. These data indicate relatively high monthly averages and maximal half-hourly SO$_2$ values, especially in the Nevah-Shaanan monitoring station, located in the high pollution area.

Table 1. Monthly averages and maximal half-hourly concentrations of sulfur dioxide ($\mu g/m^3$) in high pollution area (Neveh Shaanan) and in medium pollution area (Kiryat Ata) 1982-1984.[a]

| | 1982 | | | | 1983 | | | | 1984 | |
| | High pollution | | Medium pollution | | High pollution | | Medium pollution | | High pollution | |
Month	Monthly average	Maximal ½ hr	Monthly average	Maximal ½ hr	Monthly average	Maximal ½ hr	Monthly average	Maximal ½ hr	Monthly average	Maximal ½ hr
January	91.9	1261	18.5	311	46.8	904	35.6	277	37.9	503
February	66.0	797	15.0	198	38.5	969	31.6	118	74.3	1392
March	81.2	1989	15.8	99	38.6	1267	18.1	305	54.8	987
April	—	—	34.5	318	17.5	320	29.6	364	64.9	2083
May	24.1	1608	25.1	370	64.0	1898	27.5	896	66.1	1127
June	30.6	1500	32.8	1238	25.0	1423	30.7	521	25.0	803
July	21.4	343	21.7	377	15.8	1081	26.5	345	24.3	176
August	29.0	510	31.9	309	20.5	606	18.6	153	22.3	1086
September	30.4	1247	21.9	399	27.6	708	24.7	271	31.6	881
October	92.0	1362	16.6	378	45.0	956	20.4	179	64.0	1405
November	109.7	1792	22.4	458	61.3	1051	19.6	291	53.0	818
December	96.0	2139	16.0	596	72.4	1289	27.3	510	78.0	1087

[a] Israel standard for half-hourly concentrations of SO_2 for 99% of the time is 780 $\mu g/m^3$ and for 100% of the time is 1560 $\mu g/m^3$.

In the high pollution area, the average monthly SO_2 ranges from 15.8 to 109.7 $\mu g/m^3$, and the highest half-hourly SO_2 value recorded was 2139 $\mu g/m^3$. The Israeli half-hour standard for 99% of the time (780 $\mu g/m^3$) was violated 102 times in 1982, 42 times in 1983, and 35 times in 1984. The Israeli half-hour standard for 100% of the time (1560 $\mu g/m^3$) was violated 15 times in 1982, twice in 1983, and three times in 1984.

The monthly averages for SO_2, calculated from measurements carried out in the monitoring station located in the medium pollution area, are in the range of 15.0 to 35.6 $\mu g/m^3$. The Israeli half-hour standard for 99% of the time was violated in this station twice in 1982 and once in 1983. This monitoring station was shut down in 1984. In the low pollution area, in which air pollutants are not routinely monitored, some measurements were carried out by the Ministry of Health during April to June 1984. The values of SO_2 measured in this area (the Western Carmel) throughout these months were extremely low (less than half-hour values of 250 $\mu g/m^3$).

Health Measurements

Of the 4458 questionnaires distributed among the pupils of the participating schools, 4334 were returned, yielding a response rate of 97.2%. The age and sex distribution of the children from the three differentially polluted areas is presented in Table 2. About 75% of the children from the three areas were born in the area they lived, and about 90% of them had lived in that area for at least 6 years.

Table 2. Age and sex distribution of studied schoolchildren by residential area.

| | Second graders | | Fifth graders | | |
Area	Boys	Girls	Boys	Girls	Total
Low pollution	409	411	342	362	1524
Medium pollution	406	441	380	387	1614
High pollution	330	337	259	270	1196
Total	1145	1189	981	1019	4334

A trend of higher prevalence of most reported respiratory symptoms characterizes schoolchildren growing up in the medium and high pollution areas in Haifa. Sputum, both with and without cold, is significantly more prevalent in the polluted area (Table 3). The respiratory diseases of three or more colds a year, respiratory diseases with sputum production, bronchitis, and respiratory diseases among siblings of the studied children are significantly more common ($p = 0.04-0.0002$) among children residing in the high pollution area (and to a certain extent in the medium pollution area) than in the low pollution area (Table 4). Analysis of background variables that may influence the prevalence of respiratory conditions of the children shows that children in the polluted area are growing up in significantly more crowded and less well-heated homes, their fathers are more frequently of oriental origin, and their mothers smoke significantly less as compared with children from the two other areas (Table 5). The effect of the different prevalence of these background variables on the prevalence of respiratory problems in the three residential areas was controlled for in further analytic procedures.

It could be shown by stratification that the different prevalence of respiratory conditions among children from the three Haifa Bay residential areas remains consistent (although not always statistically significant) within the subgroups of the background variables. For instance, among children whose mothers are smokers or whose homes are crowded, the prevalence of respiratory conditions is higher in the high (and sometimes in the medium) pollution area than in the low pollution area.

The logistic models fitted for the respiratory conditions that differed significantly among the three residential areas enabled calculation of the relative risk to suffer from a respiratory condition in the high and medium pollution areas compared with the low pollution area, accounting for other environmental factors (crowding index, father's origin, and maternal smoking) which could influence the prevalence of the respiratory conditions. All the models fitted to describe the prevalence of respiratory conditions included the area of residence as a significant component (Table 6). All the

Table 3. Prevalence of reported respiratory symptoms among schoolchildren from three Haifa Bay areas.

| | Prevalence, % | | | |
| | Pollution area | | | |
Respiratory symptom	Low	Medium	High	p-Value
Cough with cold	40.4 (1433)[a]	42.6 (1548)	39.8 (1146)	NS[b] (0.2897)
Cough without cold	8.1 (1436)	9.0 (1542)	10.3 (1145)	NS (0.1648)
Sputum with cold	17.9 (1396)	23.0 (1497)	22.8 (1112)	0.0011
Sputum without cold	3.5 (1395)	4.8 (1493)	6.0 (1108)	0.0116
Cough with sputum	8.3 (1380)	9.3 (1480)	9.9(1097)	NS (0.3355)
Wheezing with cold	15.4 (1364)	15.4 (1444)	15.1 (1076)	NS (0.9776)
Wheezing without cold	7.1 (1337)	7.3 (1370)	8.4 (1061)	NS (0.4557)
Wheezing with shortness of breath	12.2 (1415)	12.5 (1512)	12.8 (1107)	NS (0.9024)

[a]Number of children in parentheses.
[b]p-Value > 0.05 is considered nonsignificant (NS).

Table 4. Prevalence of reported respiratory diseases among schoolchildren from three Haifa Bay areas.

| | Prevalence, % | | | |
| | Pollution area | | | |
Respiratory disease	Low	Medium	High	p-Value
Three or more colds/year	37.9 (1150)[a]	38.3 (1192)	45.5 (828)	0.0009
Respiratory disease	6.6 (1417)	6.8 (1521)	6.5 (1109)	NS[b] (0.9544)
Respiratory disease with sputum	3.0 (1410)	4.9 (1476)	4.4 (1100)	0.0400
Measles	8.3 (1262)	9.0 (1340)	10.3 (981)	NS (0.2648)
Sinus trouble	4.6 (1275)	3.7 (1353)	5.2 (981)	NS (0.2010)
Bronchitis	17.0 (1285)	18.0 (1390)	22.4 (996)	0.0027
Asthma	9.5 (1281)	10.2 (1371)	11.0 (990)	NS (0.5092)
Pneumonia	13.7 (1290)	16.3 (1381)	14.6 (998)	NS (0.1675)
Ear infections	36.4 (1331)	36.6 (1414)	32.2 (1043)	0.0499
Tonsilitis	5.3 (1396)	6.4 (1504)	5.0 (1091)	NS (0.2729)
Allergy	16.4 (1377)	13.4 (1502)	16.1 (1084)	0.0457
Respiratory diseases among siblings	17.3 (1350)	17.5 (1463)	23.2 (1068)	0.0002

[a]Number of children in parentheses.
[b]p-Value >0.05 is considered nonsignificant (NS).

Table 5. Distribution of background variables among schoolchildren from three Haifa Bay areas.

| | | Distribution, % | | | |
| | | Pollution area | | | |
Variable	Category	Low	Medium	High	p-Value
Crowding index	≥1.5 persons/room	28.5	32.9	42.6	
		(1393)[a]	(1522)	(1129)	< 0.0001
	<1.5 persons/room	71.5	67.1	57.4	
Household heating	Kerosene or gas	55.4	60.4	56.4	
	Other heating	37.2 (1447)	30.8 (1560)	32.9 (1153)	0.0003
	No heating	7.4	8.8	10.8	
Smoking habits in the family	Nobody smokes	37.3	37.8	39.1	
	Mother smokes	10.4 (1402)	6.6 (1520)	5.9 (1116)	0.0002
	Other smokers	52.3	55.6	55.0	
Respiratory diseases among parents	Yes	20.3	17.1	18.6	
		(1274)	(1394)	(992)	0.0975
	No	79.7	82.9	81.4	
Father's country of origin	Oriental	26.9	29.8	31.1	
		(1415)	(1539)	(1139)	0.0497
	Western	73.1	70.2	68.9	

[a]Number of children in parentheses.

Table 6. Relative risk for respiratory symptoms and diseases for second- and fifth-grade schoolchildren from three Haifa Bay areas (calculated from logistic models).

Respiratory symptom or disease	Pollution area			p-Value for area
	Low	Medium	High	
Sputum with cold	1.00	1.40	1.38	0.0007
Sputum without cold	1.00	1.36	1.81	0.0099
≥ 3 Colds/year	1.00	1.06	1.43	0.0003
Respiratory diseases with sputum	1.00	1.73	1.50	0.0248
Bronchitis	1.00	1.10	1.49	0.0008
Respiratory diseases among siblings	1.00	0.88	1.50	0.0013

models demonstrate well the interactions between the respiratory conditions and the background variables. Part of the models include, in addition to the area of residence, other background variables, especially the crowding index. The relative risks calculated for respiratory conditions in the high pollution area are between 1.38 for sputum with cold and 1.81 for sputum without cold, as compared with 1.00 in the low pollution area of Haifa Bay.

Table 7 presents results of analysis of variance of pulmonary function tests in the four groups of schoolchildren (boys and girls in the second and fifth grade) in the three residential areas. Among boys and girls from the second grade, FVC and FEV_1 values are highest in the low pollution area,

while PEF is lowest. For girls from the fifth grade, FVC and FEV_1 values are highest in the low pollution area, while PEF is lowest in the high pollution area. For boys from the fifth grade, FVC and FEV_1 values are lowest in the medium pollution area, while lowest PEF was measured in the high polluted area. The actual differences in the PFT values are small, but due to sample size many of them are highly significant statistically. All the measured values are within normal range. There is no consistent trend of reduced pulmonary function which characterizes any residential area.

The multiple regression analyses of PFT included crowding index, smoking habits of mother, father's country of origin, and residential area. These regressions could not explain the differences in PFT (low R^2 values). The residential area is included in all the regression equations but enters in a different way for the various pulmonary function parameters: for FVC and FEV_1 there is a decrease, whereas for PEF there is an increase in the medium and high pollution areas as compared with the low pollution area.

Discussion

The health data gathered from schoolchildren growing up in three residential areas of the Haifa Bay region, Israel, indicate a higher prevalence of both respiratory symptoms and respiratory diseases among those children residing in the high pollution, and to a certain extent in the medium

Table 7. Pulmonary function tests of four groups of schoolchildren in three Haifa Bay areas.

	Second-grade boys				Fifth-grade boys			
	Pollution area				Pollution area			
Test	Low (n = 399)	Medium (n = 392)	High (n = 322)	p-Value	Low (n = 329)	Medium (n = 368)	High (n = 242)	p-Value
FVC, L	1.54 (0.26)[a]	1.50 (0.28)	1.48 (0.25)	0.0060	2.18 (0.35)	2.11 (0.34)	2.19 (0.36)	0.0030
FEV_1, L	1.47 (0.23)	1.46 (0.25)	1.45 (0.24)	0.3293	2.04 (0.30)	2.02 (0.30)	2.04 (0.29)	0.4812
FEV_1/FVC, %	96.04 (5.14)	97.92 (3.86)	98.17 (6.54)	<0.0001	93.98 (7.11)	96.09 (4.93)	93.66 (6.01)	<0.0001
PEF, L/sec	3.19 (0.70)	3.38 (0.71)	3.31 (0.68)	0.0007	4.33 (0.89)	4.42 (0.82)	4.38 (0.78)	0.3247
FEF_{50}, L/sec	2.30 (0.53)	2.53 (0.59)	2.44 (0.56)	<0.0001	2.98 (0.71)	3.12 (0.68)	3.03 (0.65)	0.0161
FEF_{75}, L/sec	1.42 (0.39)	1.60 (0.42)	1.53 (0.39)	<0.0001	1.69 (0.48)	1.83 (0.52)	1.68 (0.51)	0.0001
	Second-grade girls				Fifth-grade girls			
	(n = 396)	(n = 424)	(n = 329)		(n = 351)	(n = 376)	(n = 261)	
FVC, L	1.40 (0.23)	1.33 (0.21)	1.34 (0.22)	0.0001	2.06 (0.38)	1.92 (0.34)	1.97 (0.33)	<0.0001
FEV_1, L	1.35 (0.22)	1.31 (0.20)	1.32 (0.20)	0.0145	1.97 (0.34)	1.89 (0.33)	1.90 (0.30)	0.0009
$FEV_1$1/FVC %	97.01 (4.61)	98.54 (2.59)	98.50 (2.64)	<0.0001	96.18 (5.14)	98.25 (4.79)	96.46 (5.02)	<0.0001
PEF, L/sec	2.91 (0.70)	3.06 (0.63)	3.09 (0.64)	0.0004	4.22 (0.94)	4.23 (0.93)	4.14 (0.81)	0.4316
FEF_{50}, L/sec	2.29 (0.60)	2.36 (0.52)	2.43 (0.56)	0.0038	3.11 (0.74)	3.22 (0.76)	3.09 (0.70)	0.0473
FEF_{75}, L/sec	1.45 (0.41)	1.52 (0.38)	1.52 (0.37)	0.0067	1.83 (0.52)	2.04 (0.58)	1.84 (0.55)	<0.0001

[a]Standard deviation in parentheses.

pollution area, as compared with those from the low pollution area. In other studies carried out among children in different countries, similar associations between air pollution concentrations in residential areas and prevalence of upper and lower respiratory tract illnesses could be shown (2,7,8,11,13,20–24).

In part of the studies carried out in England (11,20) and in the United States (21,23), the air pollution concentrations that were associated with higher prevalence of respiratory indices among children were much higher than the concentrations measured in our study. Other studies (2,8,22,24,25) show correlations between the prevalence of upper and lower respiratory tract symptoms and exposure to concentrations of community pollution similar to those found in our study. In the WHO collaborative study (2), exposures to yearly average values of SO_2 and smoke ranging between 50 and 200 $\mu g/m^3$ were associated with increased prevalence of respiratory indices among children. The Groupe Cooperatif PAARC in France (22) also found an association between the prevalence of upper respiratory symptoms in children and community SO_2 concentrations in the range of 13 to 127 $\mu g/m^3$. In the study carried out by Love et al. in New York (24), annual mean concentrations in the polluted community were similar to those measured in our study, and similar associations with upper and lower respiratory diseases were observed.

In a study carried out among schoolchildren residing in a polluted agricultural area in Israel (8), a significant association between respiratory conditions, such as prevalence of sputum, number of colds per year, and respiratory diseases among siblings on the one hand, and SO_2 monthly average concentrations (up to 99.5 $\mu g/m^3$) on the other, could be demonstrated.

In a study dealing with the benefits of morbidity reduction from air pollution control in the Haifa Bay area, significant correlations were found between respiratory symptoms of children living in different areas of Haifa Bay and air pollution levels (25). In the high pollution section of Haifa Bay, monthly average concentrations of SO_2 were within the range of 20 to 30 $\mu g/m^3$ in the summer months and reached up to 110 $\mu g/m^3$ in the winter.

We carried out multivariate statistical analysis which enabled control for the health effects of other environmental factors, in addition to air pollution, to which children are simultaneously exposed in the community. We used logistic models for calculating relative risks of respiratory conditions, controlling for background variables that could be responsible for the difference in prevalence of respiratory conditions among the three areas of residence. The relative risk values we found were between 1.38 for sputum with cold and 1.81 for sputum without cold in the high pollution area as compared with 1.00 in the low pollution area. Schechter (25) also reported relative risks (calculated from logistic models) for respiratory conditions in the polluted area of Haifa Bay to be 1.92 for cough or sputum without cold and 1.49 for asthma or bronchitis as compared with 1.00 in the low polluted area. (Relative risks in our study were 1.81 and 1.49, respectively.) It is interesting that these relative risk values are lower than those we found in other studies

carried out in Israel for similarly SO_2 polluted (8) and for less SO_2 polluted (7) areas.

French and his group (21), in their family study carried out in the United States, emphasize the importance of length of exposure to pollution and its correlation with respiratory conditions. Most studied children from the three Haifa Bay communities (87.7–93.5%) lived in the area for at least 6 years; the lengths of stay in the area were similar in the other studies carried out in Israel (7,8).

All the environmental health studies carried out thus far in Israel are cross-sectional surveys. Different prevalence in respiratory conditions were attributed to estimates of exposure based on community monitoring of air pollutants after controlling for other possible environmental risk factors. This cross-sectional study design and the lack of specific air pollution measurements constitute a certain limitation in these studies, and it is possible that other pollutants, either separately or in combination with SO_2, contribute to the higher relative risk values observed in prior studies (7,8). On the other hand, it is worthwhile to stress the fact that another survey carried out in the Haifa Bay region (25) elicited almost the same relative risk values for respiratory conditions among children as this study, although using different questionnaires and different analysis techniques. These relative risk values are also quite similar to those found for children by Love and his group (24) in their New York health study. Further environmental health studies planned to be conducted in Israel follow the recommendations of Lebowitz (26) to use spatio-temporal designs in the surveillance of respiratory effects of point sources of pollution.

It should be noted that the results of this study served in part to initiate the current move to lower the Israeli air quality standard for SO_2. The present tendency is to cancel the 99% standard and to adopt the level of 780 $\mu g/m^3$ (half-hour average) as the standard for 100% of the time. This modification, if approved, will constitute a positive step, but this proposed level is still higher than the WHO guidelines (27) for SO_2 of 500 $\mu g/m^3$ for 10 min and 350 $\mu g/m^3$ for 1 hr. The government decision not to build the next 1100 MW coal-fired power plant in Haifa, as approved earlier, was partly in response to growing concern among citizens about air quality in the Haifa Bay area and its health consequences.

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